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Assessment of Gas and Petrochemical Industries Impact on Environmental Pollution and Health in the Asalouye

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Abstract: This research delves into the environmental pollution arising from the gas and petrochemical industries situated in the Asalouye region, located in southwest Iran, and its consequential impact on public health, encompassing workers, their families, and other local residents. Emphasizing a thorough comprehension of the magnitude and characteristics of pollution emanating from these industries, as well as its ramifications for community well-being, the study adopts a multifaceted analytical approach. Utilizing both quantitative data analysis and qualitative evaluations, the research endeavors to elucidate the specific pollutants emitted, their dispersion dynamics, and the resultant health hazards confronting the populace. The study presents an experimental investigation into air pollution, focusing on fine particulate matter ($PM_{2.5}$ and PM_{10}) measured across coastal sediments, comprising 58 distinct samples along the Asalouye coastline. Findings reveal the pervasive environmental contamination by heavy metals and industrial particulate matter, with a reduction in risk levels observed from southeast to northwest. The concentration of environmental pollutants in the southeast area primarily correlates with the presence of major petrochemical and gas refineries in the vicinity.

Keywords: Environmental Pollution, Gas and Petrochemical Industries, Public Health, Heavy Metals, Asalouye.

I. INTRODUCTION

Environmental pollution poses a significant threat to public health, with adverse consequences reverberating across communities worldwide (Al Naggar et al. 2018; Azizpour et al. 2020; Ali et al. 2021). The Asalouye region in southwestern Iran exemplifies this intersection of industrial activity and environmental degradation, particularly attributable to its thriving gas and petrochemical industries (Nanehkaran et al. 2023). Emissions from these industries introduce a diverse array of pollutants into the surrounding environment, including airborne particulate matter, volatile organic compounds, and heavy metals, among others (Panov et al. 2008). These pollutants not only degrade air and water quality but also permeate the soil, compromising agricultural productivity and ecosystem health (Masindi & Muedi 2018).

Heavy metals, such as lead, mercury, cadmium, and arsenic, are pervasive pollutants in industrial regions, posing significant environmental and public health risks (Azizpour et al. 2020). These metals find their way into the environment through various industrial activities like mining, smelting, manufacturing, and waste disposal (Sharma et al. 2021). Once released, they can accumulate in soil, water, and air, persisting for long periods and causing a range of detrimental effects on ecosystems and human health (Nanehkaran et al. 2023). Firstly, heavy metals can disrupt ecosystems by harming plants, animals, and microorganisms. They can interfere with biological processes, impairing growth, reproduction, and overall ecosystem functioning. For example, elevated levels of lead or cadmium in soil can inhibit plant growth and reduce biodiversity, leading to cascading effects on the entire ecosystem. Secondly, heavy metals pose serious health risks to humans, especially in industrial communities where exposure levels are higher. These metals can enter the human body through various pathways such as inhalation, ingestion, or skin contact (Zaynab et al. 2022). Chronic exposure to heavy metals has been linked to a myriad of health problems, including neurological disorders, kidney damage, respiratory ailments, and even cancer.

Heavy metal contamination can have far-reaching economic consequences for industrial regions. Contaminated land and water bodies may become unsuitable for agriculture, fisheries, or recreational activities, leading to loss of livelihoods and revenue. Cleanup and remediation efforts are often expensive and resource-intensive, further burdening local economies and governments (Adeyemi & Ojekunle 2021). Moreover, addressing heavy metal pollution is crucial for sustainable development and environmental stewardship. By mitigating industrial activities' adverse impacts and implementing pollution control measures, we can safeguard ecosystems, protect public health, and ensure the long-term viability of industrial regions (Wang et al. 2020). Additionally, promoting cleaner production processes and transitioning towards renewable energy sources can help reduce heavy metal emissions and create a more sustainable industrial landscape for future generations (Sharma et al. 2021). The implications of environmental pollution on public health in the Asalouye region are profound and multifaceted. Inhalation of contaminated air exposes residents to respiratory ailments, cardiovascular diseases, and various forms of cancer, exacerbating existing health disparities within the community. Additionally, pollutants can infiltrate water sources, posing risks of contamination and waterborne illnesses. Furthermore, the cumulative effects of long-term exposure to environmental pollutants manifest in chronic health conditions, impairing quality of life and imposing substantial burdens on healthcare systems.

II. Studied Location: Asalouye

The Asalouye region, nestled in the southwestern expanse of Iran, stands as a hub of industrial activity, particularly renowned for its gas and petrochemical industries. Amidst the backdrop of economic growth and industrial advancement, concerns regarding environmental pollution and its consequential impact on public health have garnered significant attention (Azarafza et al. 2018). Figure 1 is provides the location of this study. This paper embarks on an investigative journey to unravel the intricate relationship between these industries and the environmental and health challenges they pose to the residents of the Asalouye region. Gas and petrochemical industries, vital for the region's economic vitality, are concurrently responsible for the emission of various pollutants into the surrounding environment. These emissions, comprising a cocktail of harmful substances, have the potential to degrade air quality, contaminate water sources, and compromise the ecological integrity of the region. Moreover, the adverse health effects of exposure to these pollutants extend beyond the confines of industrial compounds, affecting workers, their families, and the broader community.

Understanding the extent and nature of pollution generated by gas and petrochemical industries is imperative for devising effective mitigation strategies and safeguarding public health. Therefore, this study adopts a comprehensive analytical approach, combining quantitative data analysis with qualitative assessments, to illuminate the specific pollutants emitted, their dispersion patterns, and the associated health risks faced by the community. By doing so, we aim to provide a holistic understanding of the environmental and health challenges confronting the Asalouye region. Through this research endeavor, we endeavor to contribute valuable insights into the complex interplay between industrial activities, environmental quality, and public health outcomes in regions heavily influenced by gas and petrochemical industries. By delineating the pathways through which pollution propagates and elucidating its implications for community well-being, we aspire to inform evidence-based decision-making and foster sustainable development practices in the Asalouye region and beyond.

III. Materials and Methods

A. Study Area and Sample Collection

The study focused on the Asalouye coastline, an area known for its industrial activities and environmental significance. Detailed geographic coordinates of the sampling sites were documented using GPS to ensure precise location tracking which located form Assaluyen Gas Refinery BLUE COKE (27.46N, 52.61E) to University of Applied Sciences Assaluyeh (27.48, 52.59). The selection of the Asalouye coastline was strategic, given its unique environmental conditions and potential sources of pollution. A total of 58 sediment samples were collected from various points along the Asalouye coastline. Sampling sites were chosen to represent a range of environmental conditions and potential pollution sources, including industrial areas, residential zones, and natural regions. This diversity aimed to capture a comprehensive picture of particulate matter (PM) distribution along the coastline. Each sediment sample was collected using a stainless-steel scoop to avoid contamination. The samples were then stored in pre-labeled, airtight polyethylene bags to maintain their integrity. To prevent any changes in composition, the samples were kept at a low temperature (4°C) until further analysis. This careful handling ensured that the samples remained uncontaminated and preserved for accurate measurement. In laboratory before tests, sediment samples from the Asalouye coastline were collected and air-dried to remove moisture. These samples were sieved to isolate $PM_{2.5}$ (particles with diameters of 2.5 micrometers or smaller) and PM_{10} (particles with diameters of 10 micrometers or smaller). The sieved samples were then homogenized to ensure consistency. To extract heavy metals from these particulate fractions, the samples underwent acid digestion. This involved treating the particles with a mixture of strong acids, typically nitric acid (HNO_3) and hydrochloric acid (HCl), in a microwave digestion system to break down the particles and dissolve the metals.

B. Laboratory Analysis

Upon arrival at the laboratory, sediment samples were air-dried at room temperature. Once dried, the samples were sieved to separate fine particles, specifically focusing on $PM_{2.5}$ and PM10 fractions. Sieving was a crucial step to ensure that only the relevant particulate matter was analyzed (Zoran et al. 2020). After sieving, the samples were homogenized to ensure uniformity, providing consistency across all collected samples (Tatarko et al. 2020). Fine particulate matter ($PM_{2.5}$ and PM_{10}) was quantified using gravimetric analysis (Padoan et al. 2021). Analytical balances were used to measure the mass of particulate matter before and after filtration. High-efficiency filters were employed to capture $PM_{2.5}$ and PM_{10} particles, ensuring precise measurement. Filters were pre-weighed before use, and the sediment samples were passed through them. Post-weighing of the filters allowed for the determination of the mass of the particulate matter collected (Cichowicz & Dobrzański 2021).

For a more detailed chemical characterization of the particulate matter, samples were analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). This technique enabled the identification and quantification of metals and other trace elements within the particulate matter (dos Santos Souza et al. 2021). Spectroscopic analysis provided a deeper understanding of the composition and potential sources of the particulate matter (Correa et al. 2023). The digested samples, now in solution form, were filtered and diluted for analysis. The analysis of heavy metals was conducted using ICP-MS, a technique that ionizes the sample using a high-temperature plasma source and measures the mass-to-charge ratio of the resulting ions with a mass spectrometer. Calibration standards with known metal concentrations were used to calibrate the ICP-MS, ensuring accurate measurements (Kumari et al. 2021). The ICP-MS provided detailed spectra showing the intensity of ions corresponding to different metals. These intensities were compared to the calibration standards to quantify the metal concentrations in the samples, typically reported in micrograms per gram (µg/g) of sediment. Data validation involved checking the results against quality control samples and performing statistical analysis to ensure accuracy. Any anomalies were investigated to maintain data integrity. Quality control samples, including blanks and duplicates, were analyzed to verify the reliability of the results (Devi et al. 2020). Quality control and assurance were integral to the methodology. Calibration of instruments was performed regularly using standard reference materials to ensure accuracy. Blanks and duplicates were included in the analysis to verify precision and reliability (Nuchdang et al. 2023). Adherence to standard protocols minimized contamination and measurement errors, ensuring the credibility of the results (Sharma & Mandal 2023).

C. Data Analysis

Descriptive statistics were calculated for the concentrations of $PM_{2.5}$ and PM_{10}, including mean, median, standard deviation, and range. These statistics provided a comprehensive overview of the data distribution. Spatial distribution patterns were mapped using Geographic Information System (GIS) software, allowing for visual representation and analysis of particulate matter dispersion along the coastline. Correlation analysis was conducted to identify relationships between particulate matter concentrations and potential influencing factors such as proximity to industrial areas and wind patterns. Understanding these correlations helped in identifying the sources and behaviors of particulate matter. Regression models were developed to predict particulate matter levels based on environmental variables, offering predictive insights and aiding in future monitoring efforts. Health risk assessments were performed using established models to estimate the potential impacts of $PM_{2.5}$ and PM_{10} exposure on human health. Both carcinogenic and non-carcinogenic risks were evaluated, providing a comprehensive assessment of the potential health hazards posed by particulate matter. This risk assessment was crucial for understanding the broader implications of air pollution on public health.

Results were interpreted in the context of local environmental policies and industrial activities. Comparisons were made with national and international air quality standards to assess the severity of pollution. This contextual interpretation helped in understanding the local impact and in framing the results within a broader regulatory framework. The findings were documented in a comprehensive report, highlighting key results, discussions, and conclusions. Graphs, tables, and maps were used to visually present the data, making the information accessible and understandable. Recommendations for mitigation measures and future research were provided based on the study outcomes, offering actionable insights and directions for further investigation. This methodology ensures a thorough investigation of particulate matter in coastal sediments, providing reliable and actionable data on air pollution levels along the Asalouye coastline. The approach combines rigorous sample collection, detailed laboratory analysis, robust quality control, and comprehensive data interpretation to deliver credible and meaningful results.

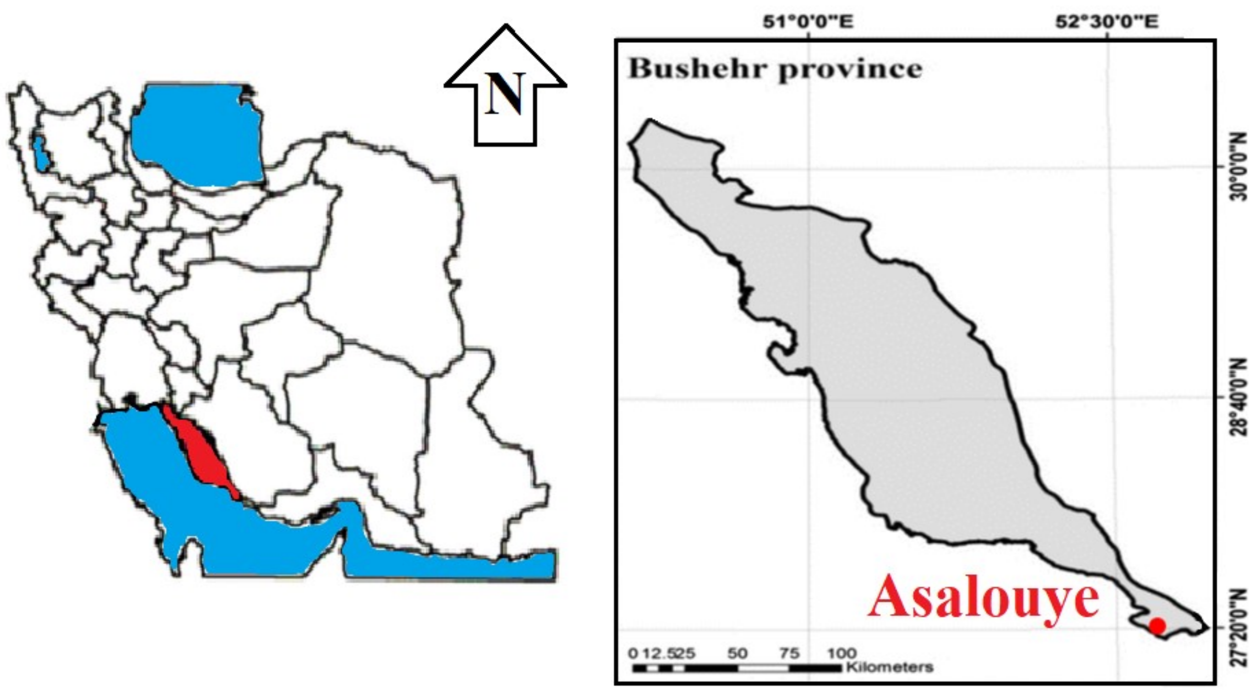

Fig. 1 Location of Asalouye region in Iran

IV. Results and Discussion

As previously mentioned, the study aims to conduct an experimental analysis of sediment and air pollution along the Asalouye coastline. The focus is on assessing the health risks posed to humans and ecosystems by existing industrial activities in the area using $PM_{2.5}$ and PM_{10} protocols. A total of 58 sites were selected along the Asalouye coastline, and samples were collected from these sites for testing purposes. Figure 2 illustrates the locations of the sampling sites along the Asalouye coastline. As depicted in the figure, the primary survey sites are situated near or close to Asalouye city, which is a hub of human habitation and is at high risk of pollution due to industrial activities. The study identifies key high-risk elements impacting human health and the environment, categorized as follows: Arsenic (As), Strontium (Sr), Tin (Sn), Silver (Ag), Antimony (Sb), Molybdenum (Mo), Zinc (Zn), Aluminum (Al), Iron (Fe), Manganese (Mn), Nickel (Ni), Vanadium (V), Cobalt (Co), Chromium (Cr), Cadmium (Cd), and Lead (Pb). Figure 3 presents the analysis results, with ground variations up to ±2 meters based on concentrations in micrograms per meter (μg/m). The samples were collected from the surface of both excavated and natural terrains along the Asalouyeh coastline, considering the ground terrain and elevation.

Figures 4 and 5 present the variations in gas emissions measured at ground level based on collected samples. The data indicates that total emissions are significantly high, reaching up to 20% saturation. Specifically, NO_x levels are up to 0.23 μg/m, SO_x levels are 0.25 μg/m, and CO_x levels are approximately 0.2 μg/m. based on the data presented in these figures reveal critical insights into the variations and levels of gas emissions at ground level. The measured samples indicate alarmingly high total emissions, with saturation levels reaching up to 20%. Such high concentrations pose significant environmental and health risks, necessitating immediate attention and mitigation measures. Specifically, nitrogen oxides (NO_x) were found at levels up to 0.23 μg/m, sulfur oxides (SO_x) at 0.25 μg/m, and carbon oxides (CO_x) at approximately 0.2 μg/m. These pollutants are known to contribute to various adverse effects, including respiratory issues, environmental degradation, and the formation of acid rain. The elevated emission levels underscore the urgent need for effective regulatory policies and technological interventions to reduce pollutant discharge and protect both the environment and public health.

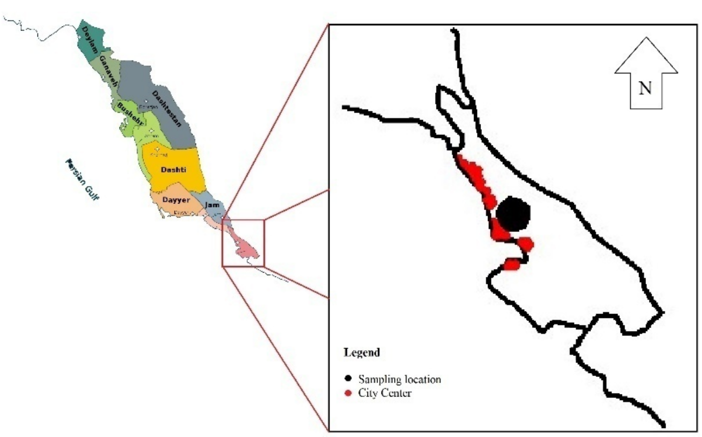

Fig. 2 Sampling location on studied area

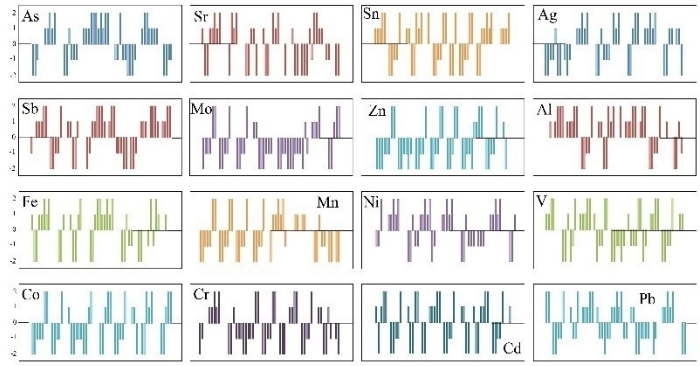

Fig. 3 Contamination measured for soil by $PM_{2.5}$ and PM_{10} for studied area (units: μg/m)

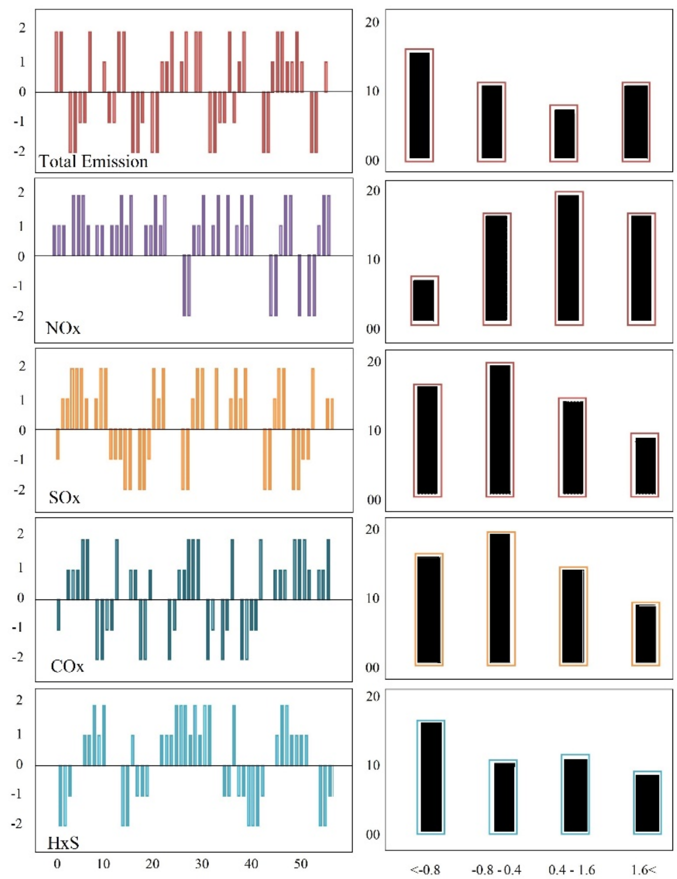

Fig. 4 Contamination measured for air by $PM_{2.5}$ and PM_{10} with frequency diagram (units: μg/m)

Figure 6 provide a detailed GIS representation of high-risk heavy metal distribution in the Asalouyeh region. The visual data clearly illustrate that the highest concentrations of pollutants in the soil and ground are predominantly located in the northwest and north sections of the area. This pattern suggests localized sources of contamination, potentially linked to industrial activities or natural geological factors in these regions. The GIS mapping reveals that arsenic (As), lead (Pb), and other heavy metals are concentrated in specific hotspots, highlighting areas that require urgent remediation efforts. The spatial distribution patterns seen in Figures 6 and 7 not only pinpoint critical zones of contamination but also serve as a valuable tool for environmental monitoring and planning. These findings can guide targeted soil testing and the implementation of pollution control measures to mitigate the adverse impacts on human health and the ecosystem. The concentration of heavy metals in the northwest and north sections of Asalouyeh poses significant environmental and public health risks. Prolonged exposure to these contaminants can lead to severe health issues, including cancer, neurological disorders, and developmental problems in children. Furthermore, the presence of these metals in the soil can affect agricultural productivity and contaminate the food chain. Therefore, it is crucial for local authorities and environmental agencies to prioritize these areas for intervention, employing strategies such as soil remediation, stricter regulatory controls on industrial emissions, and continuous environmental monitoring to safeguard the health and well-being of the population.

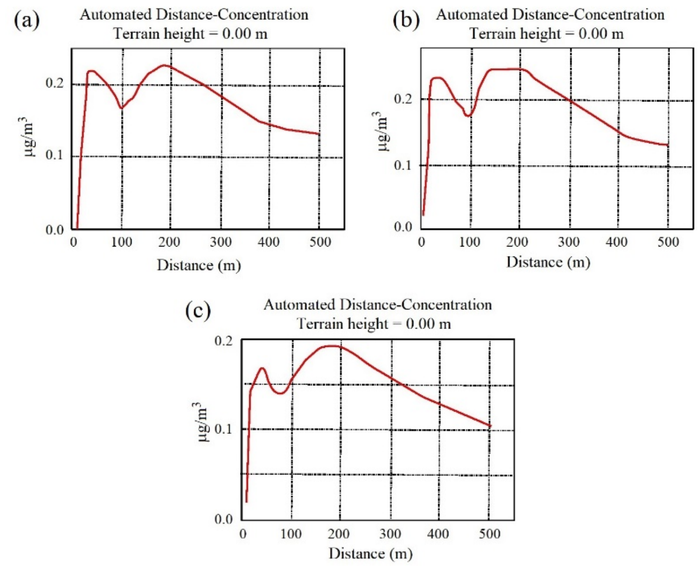

Fig. 5 The variation of main gas emission estimated on ground: (a) NO_x, (b) SO_x, (c) CO_x

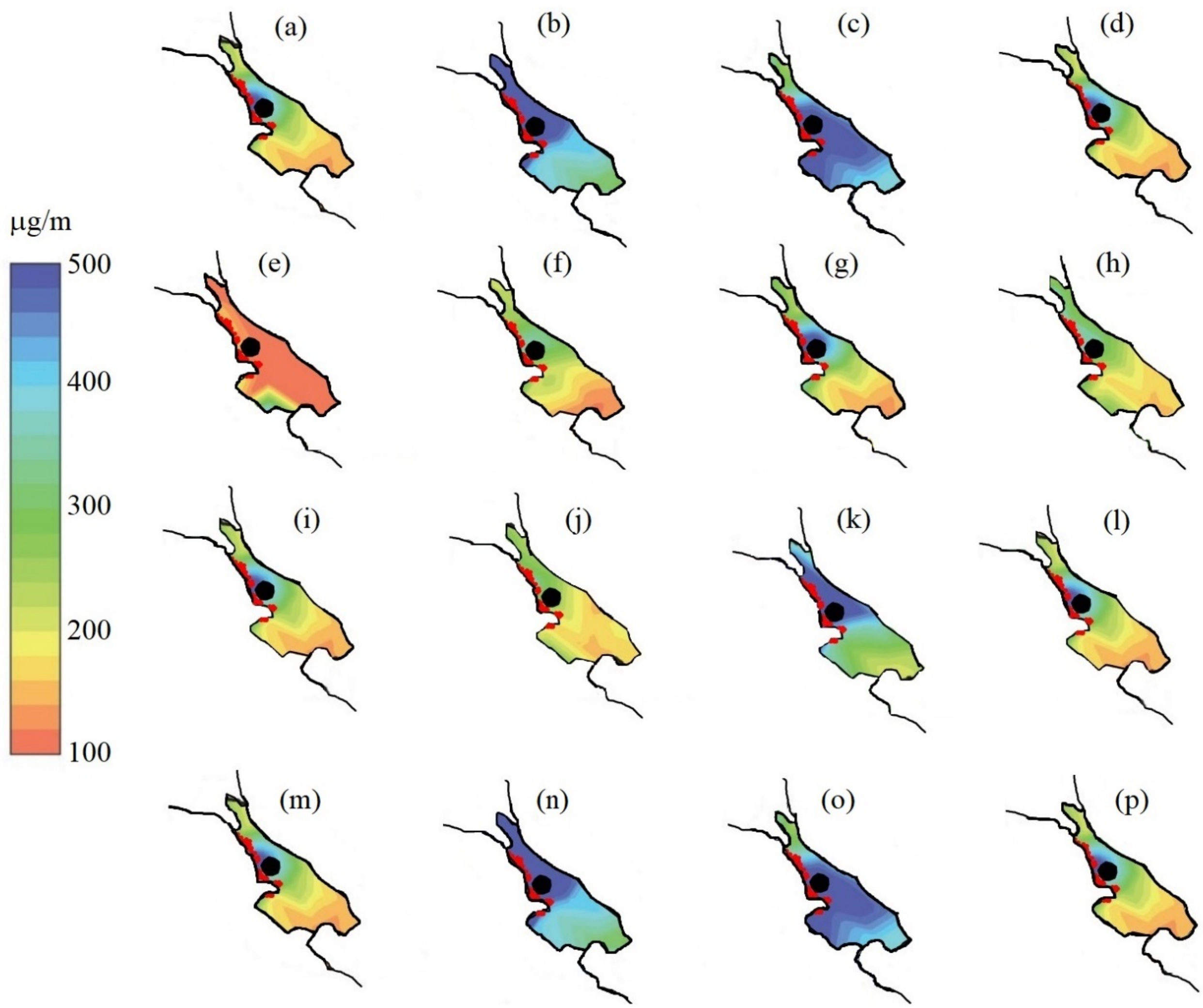

Fig. 6 Contaminated land for $PM_{2.5}$ and PM_{10}: (a) As, (b) Sr, (c) Sn, (d) Ag, (e) Sb, (f) Mo, (g) Zn, (h) Al, (i) Fe, (j) Mn, (k) Ni, (l) V, (m) Co, (n) Cr, (o) Cd, (p) Pb

V. Conclusion

This study has provided a comprehensive examination of the environmental pollution caused by the gas and petrochemical industries in the Asalouyeh region of southwest Iran and its subsequent impact on public health, particularly affecting workers, their families, and local residents. Through an integrated approach that combines quantitative data analysis and qualitative evaluations, the research has successfully identified and characterized the specific pollutants emitted by these industries, their dispersion patterns, and the associated health risks faced by the community. The findings highlight significant contamination of the environment with heavy metals and industrial particulate matter. GIS mapping revealed that the highest concentrations of heavy metals are located in the northwest and north sections of the Asalouyeh region, areas that are crucial for targeted remediation efforts. The distribution of fine particulate matter ($PM_{2.5}$ and PM_{10}) along the Asalouyeh coastline, measured from 58 distinct samples, further underscores the widespread nature of industrial pollution. Notably, the study observed a gradient in pollution levels, with a decrease in risk from the southeast to the northwest, indicating a direct correlation between pollutant concentration and proximity to major petrochemical and gas refineries. The substantial environmental contamination in Asalouyeh, as revealed by this study, necessitates immediate and sustained action. Mitigating the health risks posed by heavy metals and particulate matter will require coordinated efforts from local authorities, environmental agencies, and industry stakeholders. Strategies such as soil and air quality remediation, stringent regulatory controls on industrial emissions, and continuous environmental monitoring are imperative to protect public health and ensure the well-being of the Asalouyeh community.

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Authors' contributions

Adel Mohammadi Siahdashty and Morteza Taghizadeh Tavana conducted the main data analysis, contributed to the data collection, preprocessing, and interpretation. Adel Mohammadi Siahdashty was responsible for drafting the initial manuscript. Morteza Taghizadeh Tavana performed checks, supervision, conceptual guidance, and critical revision of the manuscript. All authors read and approved the final manuscript.

Conflict of interest

The authors have not disclosed any competing interests.

References

Adeyemi A.A., Ojekunle Z.O. (2021). Concentrations and health risk assessment of industrial heavy metals pollution in groundwater in Ogun state, Nigeria. *Scientific African*, 11, e00666. https://doi.org/10.1016/j.sciaf.2020.e00666.

Al Naggar Y., Khalil M.S., Ghorab M.A. (2018). Environmental pollution by heavy metals in the aquatic ecosystems of Egypt.*Open Access Journal of Toxicology*, 3(1), 555603. https://doi.org/10.19080/OAJT.2018.03.555603.

Ali M.M., Hossain D., Al-Imran A., Khan M.S., Begum M., Osman M.H. (2021). Environmental pollution with heavy metals: A public health concern.*Heavy metals-their environmental impacts and mitigation*, pp. 771-783. https://doi.org/10.5772/intechopen.96805.

Azarafza M., Ghazifard A., Akgün H., Asghari-Kaljahi E. (2018). Landslide susceptibility assessment of South Pars Special Zone, southwest Iran.*Environmental Earth Sciences*, 77, 1-29. https://doi.org/10.1007/s12665-018-7978-1.

Azizpour A., Azarafza M., Akgun H. (2020). The impact of municipal waste disposal of heavy metals on environmental pollution: A case study for Tonekabon, Iran.*Advances in Environmental Research*, 9(3), 175-189. https://doi.org/10.12989/aer.2020.9.3.175.

Cichowicz R., Dobrzański M. (2021). Spatial analysis (measurements at heights of 10 m and 20 m above ground level) of the concentrations of particulate matter (PM_{10}, $PM_{2.5}$, and $PM_{1.0}$) and gaseous pollutants (H_2S) on the university campus: a case study.*Atmosphere*, 12(1), 62. https://doi.org/10.3390/atmos12010062.

Correa M.A., Franco S.A., Gómez L.M., Aguiar D., Colorado H.A. (2023). Characterization methods of ions and metals in particulate matter pollutants on $PM_{2.5}$ and PM_{10} samples from several emission sources.*Sustainability*, 15(5), 4402. https://doi.org/10.3390/su15054402.

Devi N.L., Kumar A., Yadav I.C. (2020). PM_{10} and $PM_{2.5}$ in Indo-Gangetic Plain (IGP) of India: Chemical characterization, source analysis, and transport pathways.*Urban Climate*, 33, 100663. https://doi.org/10.1016/j.uclim.2020.100663.

dos Santos Souza E.J., Mora C.Z., Zuluaga B.H.A., do Amaral C.D.B., Grassi M.T. (2021). Multielement analysis of particulate matter $PM_{2.5}$ and PM_{10} by ICP OES.*Talanta*, 221, 121457. https://doi.org/10.1016/j.talanta.2020.121457.

Masindi V., Muedi, K.L. (2018). Environmental contamination by heavy metals.*Heavy Metals*, 10(4), 115-133. https://doi.org/10.5772/intechopen.76082.

Nanehkaran Y.A., Licai Z., Azarafza M., Talaei S., Jinxia X., Chen J., Derakhshani R. (2023). The predictive model for COVID-19 pandemic plastic pollution by using deep learning method.*Scientific Reports*, 13(1), 4126. https://doi.org/10.1038/s41598-023-31416-y.

Nanehkaran Y.A., Chen B., Cemiloglu A., Chen J., Anwar S., Azarafza M., Derakhshani R. (2023). Riverside landslide susceptibility overview: leveraging artificial neural networks and machine learning in accordance with the United Nations (UN) sustainable development goals.*Water*, 15(15), 2707. https://doi.org/10.3390/w15152707.

Nuchdang S., Kingkam W., Tippawan U., Sriwiang W., FungklinR., RattanaphraD. (2023). Metal composition and source identification of PM2.5 and PM10 at a suburban site in Pathum Thani, Thailand.*Atmosphere*, 14(4), 659. https://doi.org/10.3390/atmos14040659.

Padoan E., Maffia J., Balsari P., Ajmone-Marsan F., Dinuccio E. (2021). Soil PM_{10} emission potential under specific mechanical stress and particles characteristics", *Science of the Total Environment*, 779, 146468. https://doi.org/10.1016/j.scitotenv.2021.146468.

Panov V.P., Zykova I.V., Chekrenev S.A. (2008). Heavy metals: The industry and environmental protection.*Fibre Chemistry*, 40, 241-245. https://doi.org/10.1007/s10692-008-9045-2.

Sharma P., Pandey A.K., Kim S.H., Singh S.P., Chaturvedi P., Varjani, S. (2021). "Critical review on microbial community during in-situ bioremediation of heavy metals from industrial wastewater.*Environmental Technology & Innovation*, 24, 101826. https://doi.org/10.1016/j.eti.2021.101826.

Sharma S.K., Mandal T.K. (2023). Elemental composition and sources of fine particulate matter (PM2.5) in Delhi, India.*Bulletin of Environmental Contamination and Toxicology*, 110(3), 60. https://doi.org/10.1007/s00128-023-03707-7.

Tatarko J., Kucharski M., Li H., Li H. (2020). $PM_{2.5}$ and PM_{10} emissions by abrasion of agricultural soils", *Soil and Tillage Research*, 200, 104601. https://doi.org/10.1016/j.still.2020.104601.

Wang S., Kalkhajeh Y.K., Qin Z., Jiao W. (2020). Spatial distribution and assessment of the human health risks of heavy metals in a retired petrochemical industrial area, south China.*Environmental Research*, 188, 109661. https://doi.org/10.1016/j.envres.2020.109661.

Zaynab M., Al-Yahyai R., Ameen A., Sharif Y., Ali L., Fatima M., Li S. (2022). Health and environmental effects of heavy metals.*Journal of King Saud University*, 34(1), 101653. https://doi.org/10.1016/j.jksus.2021.101653.

Zoran M.A., Savastru R.S., Savastru D.M., Tautan M.N. (2020). Assessing the relationship between surface levels of $PM_{2.5}$ and PM_{10} particulate matter impact on COVID-19 in Milan, Italy.*Science of the Total Environment*, 738, 139825. https://doi.org/10.1016/j.scitotenv.2020.139825.